Transport Canada Transports Canada

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Marine Casualty Investigations

Enquêtes sur les accidents maritimes

Investigation Report to the Minister pursuant to sections 477 or 480 of the Canada Shipping Act (1985)

Rapport d'investigation au Ministre conformément aux articles 477 ou 480 de la Loi sur la marine marchande du Canada (1985)

Canada

Ce rapport est aussi disponible en français.

REPORT OF INVESTIGATION INTO THE CIRCUMSTANCES ATTENDING THE FIRE ONBOARD THE CANADIAN SELF UNLOADING BULK CARRIER "H.M. GRIFFITH" WHILE IN LOCK No. 8 OF THE WELLAND CANAL, PORT COLBORNE, ONTARIO, ON SEPTEMBER 27, 1989.

REPORT No. 540

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REPORT OF INVESTIGATION INTO THE CIRCUMSTANCES ATTENDING THE FIRE ONBOARD THE CANADIAN SELF-UNLOADING BULK CARRIER "H.M. GRIFFITH" WHILE IN LOCK No. 8 OF THE WELLAND CANAL, PORT COLBORNE, ONTARIO, ON SEPTEMBER 27, 1989.

Particulars of Vessel

Name	"H.M. GRIFFITH"
Official Number	346833
Port of Registry	Collingwood, Ontario
Call Sign	VGFJ
Gross Tonnage	22,775
Net Tonnage	16,398
Length (O.A.)	222.6 m (730'-0")
Breadth (Mld.)	22.6 m (75'-0")
Depth (Mld.)	14.7 m (46'-6")
Type of Vessel	Great Lakes Self-unloader Bulk Carrier
Material	Steel
Built	1973, Collingwood, Ontario
Propulsion	2 Crossley Pielstick diesel engines 9,000 b.h.p. total, geared to a single controllable pitch propeller, with Kort nozzle rudder.
Cargo deadweight	27,189 tonnes Beckley LA777 grade coal
Draughts (departure)	7.88 m (25'-10") F, 7.90 m (25'-11") A.
Complement	30 Crew 1 Passenger
Classification	+100A1, +LMC Lloyds
Owner	C.S.L. Group Montreal, P.Q.
Operator	Canada Steamship Lines Inc. Montreal, P.Q.

Navigating and Communications Equipment

Radar (2)	Kelvin Hughes Sperry Seathru 340
Gyro (2) & repeaters	Sperry Mk37
Magnetic compass	Sestral
VHF R/T (2)	Sailor RT 144C Collins Mk 201
Radio DF	Marconi Lodestar
Intercom (2)	Bogan DI-10 Engineered Sound Systems
Loran C	Sitex/Koden 757
Auto pilot	Sperry
Echo sounder	Kelvin Hughes

Description of Vessel

The "H.M. GRIFFITH" is a Canadian Great Lakes self-unloading bulk carrier of all-welded steel construction, built in 1973, at Collingwood, Ontario. Her basic layout is as shown in the Outline General Arrangement, (Figure No. 1), and she has two marine diesel engines with a combined reduction gearbox which drives a controllable pitch propeller in a Kort nozzle rudder.

The hull is subdivided by three transverse watertight bulkheads and is arranged with five pairs of combined double-bottom and wing water ballast tanks in way of five cargo holds. The holds are served by a total of twenty-three cargo hatches and are separated by four structural but non-watertight transverse bulkheads.

The vessel is equipped with three cargo unloading conveyor belts arranged longitudinally in a hopper-topped tunnel under the cargo holds, as shown in the Typical Hold Cross Section, (Figure No. 2). Transfer and loop belt conveyor systems are located at the after end of the tunnel in a vertical casing on the ship's centreline, which serve a swivelling unloading conveyor boom some 76 m (250'-0") in length, located above the spar deck.

Note: 1. All times in this report are expressed in Eastern Standard Time, (UTC minus 5 hours).

2. All references to the Canada Shipping Act in this report refer to Chapter S-9-1985 of the revised Statutes of Canada.

3. A glossary of abbreviations and marine terms can be found following the Findings of this report.

Background

The Great Lakes self-unloading bulk carrier "H.M. GRIFFITH", enroute from Toledo, Ohio, USA, to Hamilton, Ontario with a cargo of some 27,189 tonnes of Beckley LA777 grade coal, entered Lock No. 8 of the Welland Canal at 1225, September 27, 1989. At 1230, black smoke was seen emerging from the extraction fan ventilators at the after end of the cargo conveyor belt tunnel, and the ship's general alarm was sounded.

A ship's fire-fighting team entered the forward end of the tunnel and found dense black smoke accumulating at its after end. The Port Colborne Fire Department (PCFD) was called, arrived on-scene at 1301, and joined the crew in their attempts to locate and douse the source of the smoke which was on the port side of the conveyor tunnel at the mid-length of Hold No. 3. Fire-fighting efforts continued as the ship's fire hoses were employed in the tunnel, through the loop belt casing entrance immediately forward of the main engine-room, and on the exposed coal cargo in No. 3 hold.

Due to the accumulation of fire-fighting water being pumped onboard, the vessel's draught was increasing, consequently at 1630, she was manoeuvred stern first out of the lock and taken to Coal Dock No. 16 where she was secured starboard side to at 1827.

Sometime after leaving Lock No. 8, water ballast was pumped into No. 4 P. & S. ballast tanks, the vessel developed a slight trim aft and the expended fire-fighting water on the tank top accumulated at the after end of the conveyor tunnel. At about 2000, while alongside Coal Wharf No. 16, some water ballast was pumped into the tunnel. The vessel subsequently took on a slight list and the accumulated water on the tank top gravitated to port, effectively submerging most of the burning conveyor belts. Shortly afterwards the amount of smoke reduced, the fire was brought under control and officially considered to be out at 2300. PCFD and ship's personnel remained on stand-by throughout the early hours of September 28, and were eventually stood-down at 0600.

In order to prevent any pollution, the contaminated fire-fighting and wash-down water in the tunnel was subsequently pumped ashore into tanker trucks and transported by road to an approved disposal area.

There were no significant injuries to ship or PCFD personnel incurred during the fire-fighting efforts, however two of the ship's crew required attention for medical conditions reported sometime after the incident.

There was extensive fire damage throughout the conveyor tunnel area and repairs costing approximately $2.1 million were completed before the vessel returned to service November 11, 1989.

Since 1975, there have been six reported fires in the cargo conveyor belt systems of Canadian Great Lakes self-unloading vessels, and this is the second major fire attributable to hot-work debris to have occurred while a vessel was in the Welland Canal system. Because the equipment requires constant routine maintenance involving hot-work, the cargo conveyor tunnel area is vulnerable to fire which, once established, is difficult to approach and extinguish.

Narrative

At 1320, September 26, 1989, the Great Lakes self-unloading bulk carrier "H.M. GRIFFITH" sailed from Toledo, Ohio, USA, with a cargo of some 27,189 tonnes of Beckley LA 777 grade coal, bound for Hamilton, Ontario. The vessel arrived off Port Colborne, Ontario, at 1140, September 27, and entered Lock No. 8 of the Welland Canal at 1225.

Shortly before 1230, two of the crew who had been engaged on routine maintenance and repair work in the conveyor belt tunnel under the cargo holds until noon, returned from lunch, and before resuming work called for the extractor ventilation fans to be run in order to clear the space of welding and burning fumes. (See photograph No. 4). At 1230, dense black smoke was seen emerging from the after ventilators, the general alarm was sounded, and the crew reported to their emergency muster stations. (See photograph No. 1).

A fire-fighting team entered the forward end of the tunnel by the only smoke free access, and found dense smoke extending from its after end to about the midlength of No. 3 hold. The forward ventilation supply fans were started to help force the smoke toward the after end of the tunnel, and a 25 mm (1") diameter wash-down hose was rigged on the port side of the tunnel, taken to the area of densest smoke and directed toward the apparent source.

While the ship's fire main was being pressurised and fire hoses rigged, the Port Colborne Fire Department (PCFD) was alerted at 1254, and arrived at Lock No. 8 at 1301. The firemen boarded the vessel and entered the forward end of the tunnel where, guided by ship's personnel, they directed a newly rigged fire hose at the source of the smoke. The volume of smoke increased steadily and

despite using breathing apparatus the firemen and crew were unable to approach the source to extinguish the fire and prevent its growth toward the forward and after ends of the tunnel. The smoke eventually bypassed a water screen directed from a fire hose fog nozzle, the tunnel main and emergency lighting systems went out and the forward ventilation fans stopped as the electrical wiring system became affected by the intense heat near the source of the fire. A propane-fueled engine-driven generator together with two portable smoke control fans were brought onboard by the PCFD. The fans were placed on the tank top at the forward end of the tunnel and arranged as substitutes for the inoperative ship's forward ventilation units. Fire-fighting was continued from the forward end of the tunnel by relays of firemen and crew using breathing apparatus and headset lights, while the extraction ventilation fans at the after end were kept running in an effort to remove smoke and enable the source to be more closely approached from forward.

Dense smoke continued to be emitted from the tunnel and several smoke detector alarms in the wheel-house, accommodation spaces, electrical control room and engine-room were activated by drifting smoke entering through unsecured doors and window openings. These alarms were then intentionally de-activated as they proved distractive to the ship's and fire-fighting personnel. (See photograph No. 2).

As a preventive measure to contain the fire and to protect the conveyor belt loop system at the after end of the tunnel, two fire hoses were deployed at the port and starboard sides of the unloading hopper housing, and another through the access door on the port side of the loop belt casing at spar deck level. Wash-down piping installed abaft the loop belts at about one third of the height of the loop belt casing was not utilised as it was considered that protection of the loop belts was better served by the fire hoses spraying water on their forward face from spar deck level. Because of concern about heat build-up under the partially filled No. 3 hold, No. 13 hatch cover was removed and 2 fire hoses used to spray water on the lightly covered tunnel top plating and the adjacent surface of the coal cargo at the mid-length of the hold.

Due to the accumulation of water being pumped onboard, the vessel's draught was increasing and gave rise to concern regarding under-keel clearance in way of the lock entrance sill. Consequently at 1630, she was manoeuvred stern first out of Lock No. 8 and shifted to Coal Dock No. 16, where she was berthed starboard side to at 1827. (See Figure No. 3). While in Lock No. 8, the vessel's windlass, forward mooring winches and bow thruster became inoperative as electrical power supply was lost due to fire damage to their main supply cables located along the port side of the conveyor tunnel. Consequently, the vessel was shifted astern by using the available midship and after mooring winches in

conjunction with her main engines, while the tug "ARGUE MARTIN" stood-by in case of need.

Fire-fighting was partially interrupted during the ship relocation, and sometime before securing at the dock, attempts were made to fill the combined wing and double bottom ballast tanks in way of the fire in order to dissipate some of the heat, reduce heat transfer to the coal cargo and counteract the free-surface effect of the water on the tank top. Because the hydraulic piping system controlling the ballast piping valves was located in the tunnel it was affected by the intense heat, control of the ballast pumping system from No. 4 P. & S. ballast tanks forward became erratic, and eventually (except for No. 3 S tank), inoperative. Reportedly water ballast tanks No. 4 P. & S. were partially filled to a depth of some 3 m (10'0"), causing the vessel to trim slightly by the stern. The expended fire-fighting water gravitated aft and began to accumulate on the tank top at the after end of the tunnel.

Large volumes of black smoke continued to emerge from the tunnel after ventilators, giving concern that the updraught chimney effect of the loop belt casing at the after end of the tunnel would propagate the spread of the fire and endanger the machinery and accommodation spaces. (See photograph No. 3). Consequently, the engine-room staff removed a non-return valve and spectacle flange from the port side tunnel bilge suction and jury-rigged the piping in the engine-room so that the tunnel could be partially flooded in the event that the fire extended to the loop belt. As a further precaution, three engine-room fire hoses were made ready to spray water onto the engine-room forward bulkhead should it become over-heated by the fire.

Shortly after 1830, in order to more closely approach the source of the fire, the tunnel was entered by way of a vertical maintenance trunk located at the after end of N° 2 hold, to starboard of the centre line conveyor belt. Access from the spar deck to the tunnel was made by means of a rope ladder suspended in the trunk, however this approach was considered unsafe and as the fire hose could not be effectively deployed, it was subsequently abandoned in place. Some time later, observations in way of the trunk showed that the tank top was covered with approximately 75 mm (3") of expended fire fighting water.

While water was being directed into No. 3 hold to counteract the effects of the hot tunnel top plating under the coal cargo, a shoreside clam-grab crane was concurrently employed to remove some of the cargo. Hatch covers Nos 11 and 12 were removed to increase ventilation and dissipation of any methane gas accumulation above the heated coal cargo. As cargo discharge continued, the vessel's after trim increased slightly and more expended fire-fighting water accumulated on the tank top at the after end of the conveyor tunnel.

Although contained within the conveyor tunnel the fire was still burning steadily and at about 2000, following a bridge conference including the master, ship's officers, owners' technical staff, SLSA representative and the PCFD fire chief, a decision was made to partially flood the tunnel in order to extinguish the fire. Flooding by way of the jury-rigged bilge piping was commenced and was then stopped after about 10 minutes. At about this time it was discovered that while ballasting No. 4 P and S tanks, ballast water had also entered Nos. 2 and 3 ballast tanks because of fire damage to the ballast valves hydraulic controls, which prevented the forward tanks being completely closed-off. In order to correct a slight starboard list taken by the vessel, some ballast was pumped from No. 3 S tank, and the accumulated water on the tank top then gravitated to port effectively submerging most of the burning conveyor belts.

Thereafter there was a marked reduction in the volume of black smoke emerging from the tunnel, and at about 2200, white acrid smoke was also seen emerging from the loop belt casing doorway. Fire-fighters entered the tunnel, extinguished some smoking electrical cables on the port side of the tunnel deckhead and noted that the accumulated fire-fighting water on the tank top extended forward of the burn damage to the port side conveyor belt. The water was estimated to be about 1.15 m (3'9") deep at the after port side of the tunnel, and submerged the port side and centre-line conveyor belts to slightly forward of midships.

At about 2300 the fire was officially considered out, and from 0030, September 28, the fire-fighters were progressively stood-down. Eight PCFD firemen and three ship's personnel maintained a firewatch, remained on stand-by throughout the early hours and were eventually stood-down at about 0600.

Cargo unloading by clam-grab crane recommenced at about 0900, September 28, and continued until September 30, by which time the centre of No. 3 hold was clear of coal and the tunnel top and cargo hopper doors were open to inspection. In order to prevent any pollution, the contaminated fire-fighting water in the tunnel was pumped ashore into tanker trucks and transported by road to an approved disposal area. The pumping and road transportation continued until October 3, by which time a total of some 1626 tonnes of fire fighting, flooding, bilge and wash-down water had been removed from the vessel. (See photograph No. 5).

There was no loss of life or serious injuries incurred during the fire-fighting, however, two of the ship's personnel required some attention for medical conditions related to, but not reported until sometime after, the incident.

Analysis

1. Fire Damage

The extent of fire damage was largely confined to the structure and ship's systems in the conveyor tunnel located below the loaded cargo holds. Painted surfaces and fittings in the accommodation spaces, bridge front, cargo boom conveyor casing and spar deck in way of the tunnel exhaust ventilators outlets incurred only superficial smoke and soot damage. There was no significant smoke damage in the engine-room and casings or to the machinery and systems in those spaces.

Examination and post-casualty testing of the ship's structure and systems showed extensive fire, smoke and water damage throughout the conveyor tunnel area which included:

a) Fire damage to the port side cargo conveyor belt and its rubber sheathed rollers extended from the mid length of No. 2 hold to the mid-length of No. 4 hold, a distance of some 76 m (250 ft).

b) Fire damage to the centre cargo conveyor belt and its rubber sheathed rollers extended from the after end of No. 2 hold to the aft end of No. 3 hold, a distance of some 37 m (120 ft).

c) Smoke and water damage to the port, centre, starboard and transfer cargo conveyor belts electrical controls, drive and clutch units at the after end of the tunnel.

d) Fire and heat distortion damage to 39 cargo hopper unloading gates and their hydraulic controls, cylinders and piping systems in way of Nos. 2, 3 and 4 holds.

e) Fire damage to the hydraulic control piping, solenoids and actuators for the remote operation of the ballast main suction valves located in the P. & S. ballast tanks.

f) Fire damage to the hydraulic control piping, solenoids and actuators for the remote operation of the ballast tanks stripping line valves in the P. & S. ballast tanks.

g) Fire damage and rupture of the 16" diameter plastic pipe ballast stripping lines in Nos. 2,3 and 4 P ballast tanks.

h) Fire damage to the cargo hopper vibrators, hydraulic piping and control system in way of Nos. 2, 3, 4 and 5 holds.

i) Fire and heat damage to the main electrical cables in the conveyor tunnel supplying power to the windlass, bow

thruster, forward mooring winches, and forward tunnel ventilation fans.

j) Fire, heat, smoke and water damage to the conveyor tunnel lighting, emergency lighting, conveyor controls, telephone intercom and General Alarm systems.

k) Heat damage to steel seatings and support structure on the port side of the tunnel, and access manhole gaskets of No. 2, 3 and 4 P ballast tanks.

l) Smoke and heat damage to the exhaust ventilation fans at the after end of the conveyor tunnel.

Those repairs necessary for the operation of the vessel and the safe working of the cargo unloading conveyor systems were carried out alongside Coal Wharf No. 16 prior to the vessel completing her interrupted voyage to Hamilton, Ontario. Having discharged her coal cargo, repairs reportedly costing slightly more than two million dollars were completed, and the "H M GRIFFITH" returned to service November 11, 1989. (See photographs No. 6 to 9).

2. Conveyor belt material ignition tests

The conveyor belt material installed in the vessel is 2.13 m (84") wide and nominally 16 mm (5/8") thick. It is known as "Boat Belt" and designated Plylon, Style B, 5 ply, RAC Grade 2 belting. It is made with 8 mm (5/16") and 1.6 mm (1/16") thick friction and skim coats of styrene butadiene rubber compound, over a woven nylon carcase core, and is recommended by its manufacturer for use with materials which do not exceed 95°C (200°F) and in atmospheric temperatures not below -40°C (-40°F).

Post-casualty ignition testing of a typical sample of cargo conveyor belt from the "H.M. GRIFFITH" was carried out on an ad-hoc basis at the National Research Council Canada, Institute of Research in Construction, (NRC), laboratory in Ottawa.

To simulate the actual working configuration as closely as possible, the conveyor belt sample was set up on a wooden jig under an oxy-acetylene cutting torch, in order that hot metal slag and sparks from a 25 mm (1") thick steel plate could fall approximately 500 mm (20") onto the belt's upper surface. Despite being repeatedly exposed to falling and accumulating slag and sparks for periods of 8 to 10 minutes, the sample did not ignite or show any significant burn damage. Similar tests were carried out with the sample surface contaminated with a film of oil similar to that used in the vessel's

hydraulic systems, also with a light covering of small coal particles and dust, and finally with a combination of oil and coal dust. All of these tests proved unsuccessful, in that the belt was not ignited, nor was its surface damaged to any significant extent.

Further tests were carried out in which dry and slightly oily cotton rags similar in size to those used for cleaning and masking purposes on the vessel, were draped over the edge of the sample belt and set alight. Flames from the rags quickly spread along the exposed edge of the belt and then spread to the upper and lower surfaces. Within some 2 minutes, ignition of the conveyor belt surfaces was well established and was allowed to continue until intentionally extinguished approximately 15 minutes later, by which time sustained ignition of both surfaces had spread well clear of the burnt-out rag.

Additional testing was carried out with lighted dry and oily rags placed on the upper surface near the centre and clear of the edges of the belt. In this instance, the belt material ignited under the burning rag but ignition was not sustained and self-extinguished shortly after the rag burnt-out, leaving only minor surface damage.

Reportedly, the edges of the conveyor belts are subject to chafing during cargo unloading operations and are routinely cut and trimmed free of the frayed rubber and nylon core materials. The edges of the sample when tested, were in a similar trimmed condition, with exposed but no frayed core material in way of the burning rags.

The prolonged exposure of the conveyor belt surface to direct contact with hot metal slag and sparks deposited during the ad-hoc tests exceeded that normally occurring during routine onboard repairs or during the morning preceding the fire, and consequently these are not considered to be the likely cause of the fire. However, the tests did show that the conveyor belt material is readily ignited by a relatively small naked flame coming in contact with the trimmed edge and exposed nylon core fabric, and is therefore considered to be the most likely location of the start of the fire.

3. Cause of fire

Wear and tear in the severe operating conditions in the tunnel, together with damages induced by the cargo vibrator system require continuous attention. Oxy-acetylene, welding and metal grinding equipment are regularly employed by the ship's personnel during routine maintenance and onboard repairs to the conveyors and hydraulic systems while the

vessel is underway. Reportedly, a dampened cloth is usually spread over the conveyor belts to protect them from hot slag and sparks generated by adjacent prolonged oxy-acetylene burning or welding.

Routine repairs by two of the ship's personnel involving oxy-acetylene burning and welding preparation were carried out throughout the morning of September 27. Metal grinding preparation for welding repairs to the centre conveyor was carried out near the mid-length of N° 1 hold, and shortly before noon the tunnelman made his way aft along the port side of the tunnel on his way to lunch. On passing the other tunnelman near the mid-length of N° 3 hold, he was instructed to take a nearby empty 9.08 kgs (20 lbs) dry chemical fire extinguisher to the engineer's store on the spar deck and replace it after lunch with a fully charged unit.

At that time oxy-acetylene burning was only required to cut and free a small split pin in way of the port side cargo gate N° 10 of N° 3 hold, and a conveyor belt protection cloth was not secured in place. Having cut through the pin the remaining tunnelman turned off the cutting torch, secured the acetylene and oxygen gas storage cylinders and went to lunch. It is likely that unnoticed in the dimly lit tunnel, sparks or hot slag were sprayed onto a discarded cleaning cloth lying nearby on the tank top, causing it to smoulder and then burst into flame after the tunnelman had left the scene. The lower layer of conveyor belt is only 150 mm (6") above the tank top and flames from the burning cloth coming in contact with it would, as post-casualty testing shows, quickly creep along it's inboard edge and spread to its upper and lower surfaces causing it to fully ignite.

It is considered that the fire started on the port side conveyor belt at the mid-length of N° 3 hold, and became established between 1200, and 1230 while the tunnelmen were at lunch and the tunnel unoccupied. In this regard, the Safe Working Practices Regulations state, in part:

> Fire Prevention and Protection
>
> 34. Whenever hot work is to be performed in a working area;
>
> a) a qualified person shall be assigned to patrol the working area and adjoining areas and maintain therein a fire protection watch for the duration of the work and for a period of 30 minutes thereafter; and
> b) sufficient fire extinguishers shall be provided in the working area and adjoining areas.

Furthermore the Marine Occupational Safety & Health

Regulations, Part IX, Confined Spaces state in section 9.5

Hot Work Operations

(2) Where hot work is to be performed in a confined space.

(a) a qualified person shall patrol the area surrounding the confined space and maintain therein a fire protection watch until all hazard of fire is passed; and
(b) fire extinguishers shall be provided in the area referred to in paragraph (a).

No one was assigned to maintain a fire protection watch upon completion of the hot work, and the only fire extinguisher remaining in the tunnel was that adjacent to the other work site where metal grinding had been carried out.

As the fire became established, the oxy-acetylene equipment left near the apparent source gave rise to the concern that it might explode. Reportedly, as the cutting torch hoses burned, the pressure in the heated cylinders was released in a controlled manner by automatic safety valves, and it is likely that the released gases together with spilled oil from adjacent fire damaged hydraulic systems contributed to the spread of the fire to the centre conveyor belt.

4. Fire fighting efforts

On being alerted at 1254, by the SLSA relaying a request from the vessel, the PCFD responded and arrived at Lock N° 8 at 1301, with rescue, pumper and aerial ladder vehicles together with a "carousel" air compressor. During the fire fighting efforts this latter unit was used to re-charge 182 expended breathing apparatus air cylinders used by the ship's crew and PCFD firemen. At approximately 1320, a foam engine with 57 @ 27 l (5 gal) pails of foam concentrate was on-site which, together with an ambulance from the Port Colborne Ambulance Service, remained on standby in case of need, until the fire was extinguished.

Fire-fighting efforts were maintained in conjunction with ship's personnel until shortly before midnight, during which 13 full time and 41 volunteer firemen were employed.

Having ordered the general alarm sounded, the master set up a command post on the bridge to coordinate the fire-fighting efforts. Communication between ship's personnel and PCFD firemen was effectively maintained with compatible "walkie-talkie" radios, while progress reports were made and subsequent actions planned at meetings held on the bridge

Access ladders are located at each end of the 189 m (612 ft) long conveyor tunnel, the forward one being some 91 m (300 ft) from the apparent source of the fire, and the design of the unloading system and loop belt casing at the after end is such, that it cannot be closed airtight in the event of fire. (See photograph No. 12). Because of concern that the intense heat in the tunnel would ignite the coal cargo, fire-fighting efforts were concentrated on delivering as much water as possible towards the source, and in preventing the fire spreading aft into the loop belt casing. These measures restricted the fire to the tunnel but did not extinguish it, and because of the intense heat and smoke, the source could only be safely approached from forward while the tunnel ventilation system was kept running.

While those directing the fire-fighting efforts were aware that air supplied by the tunnel ventilation fans would help sustain the fire, they were faced with the dilemma of either abandoning the fire in the unsecured tunnel and leaving the loop belt casing and coal cargo at risk, or continuing to direct water toward the source in an effort to contain and eventually extinguish the fire. In the event, the accumulation of water on the tank top was such that a further option became possible, and after fighting and containing the fire for some seven hours, the decision was taken to partially flood the tunnel by way of jury-rigged bilge piping and extinguish the fire by completely immersing the burning conveyor belts.

5. Ballast piping systems

Prior to her completion in 1973, the vessel's Pumping Plan incorporating unplastized polyvinylchloride (PVC) ballast piping, was approved by the Board of Steamship Inspection, Department of Transport. Following its introduction and development, the adoption of PVC piping gradually increased and in 1977, the Ship Safety Branch of Canadian Coast Guard issued TP 1083, "Standard for Plastic Piping", establishing criteria for its approval and compliance with the requirements of the Hull Construction Regulations of the Canada Shipping Act.

In this regard, the Forward of TP1083 states in part:

> In considering any application for the use of non-metallic piping, the Board pays particular attention to the structural and fire integrity of the vessel, and conditions which might arise affecting the safety of the ship and personnel.....
> ..... In particular, the arrangement of the system must provide an equivalent measure of safety with respect to

sub-division, inroads of the sea and structural fire protection to that envisaged in the Hull Construction and Load Line Regulations.

Chapter 5 of the General section of TP1083 states in part:

5. (1) Rigid plastic piping may be used for domestic and other services as follows:

(g) Water ballast and freshwater pipes situated inside tanks used exclusively for water ballast or fresh water.

The Installation section of TP1038 states in part:

7. (1) Where rigid plastic piping as prescribed by Section 5 is to pass through a water-tight or fire-resisting bulkhead or deck, provision shall be made for maintaining the integrity of the bulkheads or decks in the event of pipe failure to give an equivalent measure of safety as that required in the Hull Construction and Load Line Regulations, in accordance with the following paragraphs:

(a) The penetration of any water-tight or fire-resisting deck or bulkhead shall be accomplished by using a steel spool-piece or other acceptable metallic fitting welded or otherwise attached to the bulkhead or deck by an acceptable method.

(b) Except as expressly provided by paragraph (e), an acceptable metallic shut-off valve shall be installed adjacent to the through bulkhead spool-piece or fitting. This valve shall be operable from above the bulkhead deck.

(e) Plastic piping used for water ballast or fresh water service situated inside tanks used exclusively for carrying water ballast or fresh water need not be fitted with shut-off valves adjacent to the through bulkhead spool-piece or fitting.

The 510 mm (20") diameter ballast main, 355 mm (14") diameter branch pipes and valves of the "H.M. GRIFFITH", are located inside the water ballast tanks and are of steel construction throughout. The port and starboard ballast mains extend forward from the engine room, are continuous through the ballast tanks with no isolating valves at the tank division bulkheads, and ballasting control valves are fitted in the branch pipes in each tank. The 406 mm (16") diameter ballast

tank stripping pipes and 305 mm (12") branch suctions are similarly arranged, with the 406 mm (16") diameter main made up with Series 125 PVC piping fitted between welded steel spool pieces in way of the ballast tank divisions. The hydraulic actuators for the butterfly valves fitted in the ballasting and stripping branch pipes are also located inside the ballast tanks, while the hydraulic piping system providing for their remote operation and control from the bridge and control room is arranged to port and starboard inside the cargo conveyor tunnel. (See Figure No. 2).

The materials and arrangement of the ballast stripping piping system fitted in the "H.M. GRIFFITH" in 1973, anticipated and are in accordance with the requirements of TP1083, issued in 1977. However, because of the proximity of the 406 mm (16") diameter PVC piping to the tunnel side, it was subjected to heat from the intense fire in the adjacent cargo conveyor tunnel, and when it buckled and ruptured in Nos. 3 and 4 port side ballast tanks, water ballast gravitated from the partially filled No. 4 P tank into No. 3 P tank. (See photographs Nos. 10 & 11). The quantity of gravitating water was such that the depth of flooding in No. 3 P ballast tank remained below tank top level, causing a substantial increase in free-surface effect and contributed to the reduction of the vessel's tranverse stability. Furthermore, the location of the hydraulic piping system serving the ballast main and stripping branch piping butterfly valve actuators make it highly vulnerable in the event of fire in the cargo conveyor tunnel which, once damaged, led to the loss of control of the vessel's ballasting systems. (See photograph No. 13). While No. 4 P & S tanks were being ballasted and later when attempting to extinguish the fire by initiating a port list some ballast water also entered Nos. 2 and 3 tanks by way of inoperative and unsecured butterfly valves in the ballast main branch pipes.

6. Tunnel fire-fighting equipment

The vessel's outfit of fire-fighting equipment and portable fire extinguishers was generally in accordance with the details listed on the Fire and Washdeck Line plan. The fire extinguishers were serviced prior to the opening of the 1989 Great Lakes shipping season and, together with the remainder of the outfit of fire-fighting equipment, found satisfactory at the vessel's annual safety inspection by the Ship Safety Branch of Canadian Coast Guard, March 30, 1989.

The cargo conveyor tunnel and loop belt casing areas are not fitted with any smoke/fire detection, sprinklers or inert gas smothering systems, nor are they required by regulation.

The vessel's Fire and Washdeck Line plan details 8 @ 15 m (50'0") and 6 @ 7.6 m (25'0") lengths of 25 mm (1") diameter 3 ply water hoses for washdown and fire extinguishing services in the cargo conveyor tunnel and loop belt casings, however, no portable fire extinguishers are listed and none were permanently installed. When the fire was first detected, the 50 mm (2") diameter fire main on the port side of the tunnel was already pressurised, but only one 15 m (50'0") length of 25 mm (1") diameter hose was available in the tunnel for immediate use. This hose was generally used for washdown and housekeeping purposes and was routinely removed and reconnected to the tunnel hose valve nearest the area to be cleaned. Water for fire-fighting and washdown services is supplied by 89 mm (3½") and 50 mm (2") diameter fire and wash deck mains of steel construction which extend forward from the engine room to the forward end of No. 1 hold, and are located on the deckhead of the cargo conveyor tunnel, to port of the centre conveyor belt. The 89 mm (3½") diameter main is fitted with nine 50 mm (2") diameter branch pipes which are led across the tunnel deckhead and through the ballast tanks to fire hydrants on the port side of the spar deck. The 50 mm (2") diameter tunnel main is fitted with 25 mm (1") diameter branch pipes arranged near the mid-length of each hold, which are led to port and starboard hose valve connections located inside the cargo conveyor tunnel. (See Figure No. 2).

The mains and branch pipes directly over the fire in the tunnel were not adversely affected by the intense heat, and water supply was not interrupted during the fire-fighting operations. However, hot steam initially discharged from spar deck hydrants above and just forward of the fire source, created some hazard for fire-fighters.

The hydraulic piping systems and cylinders of the cargo hopper doors require constant maintenance and repair because of vibration induced damage, and hydraulic and cleaning fluids are frequently leaked or spilled in the tunnel and onto the tank top. It was normal practice for the tunnelmen to have either a 4.54 kgs (10 lbs) or 9.08 kgs (20 lbs) capacity dry chemical extinguisher nearby whenever maintenance or repairs involving hot-work were carried out, and these were usually kept in the engineer's store on the spar deck, adjacent to the port side access door of the loop belt casing. Reportedly, these extinguishers were routinely used to douse small flare-ups resulting from hot-work sparks or slag coming in contact with spilled oils and cargo debris, however, none had occurred recently and the extinguishers were not used before noon on the day of the fire. No record of these small fires was kept nor were they regularly reported, having become a routine and not infrequent occurrence.

The absence of smoke/fire detection and alarm systems, difficulty of access and limited scale of fire-fighting equipment in the tunnel were such, that in the event of fire, conventional fire-fighting efforts were delayed, hazardous and largely ineffective. Furthermore, the location in the tunnel of the hydraulic control piping systems of the ballast and stripping branch pipe valves and the electrical power supply line to the bow thruster, windlass, and forward mooring winches made them vulnerable to fire damage, and in the event, these soon became inoperable.

7. Stability

Upon completion in 1973, the Canadian Great Lakes self-unloading vessel "H.M. GRIFFITH" was not the subject of an inclining experiment and a trim and stability booklet was not prepared, nor were they required by regulation. At the time of the fire, copies of basic hydrostatic information and tanks capacities data prepared for sister-ships by the same builder, were onboard for the guidance of the master.

Reportedly, the vessel was loaded with a total of 560 tonnes of stores, spares and consumables together with some 92 L tons of water ballast and 27,189 tonnes of coal cargo distributed in the five holds, as shown in Figure No. 1. Post-casualty calculations based on sister-ship lightship and hydrostatics characteristics and the reported deadweight, confirm the arrival draughts of 7.88 m (25'-10") forward, and 7.90 m (25'-11") aft. The precise location of the vertical centre of gravity of the cargo in each hold is unknown, however, based on conservative estimates, the vessel's initial transverse stability may be reasonably derived. Taking into account the free-surface effect of fresh water and oil fuel tanks known to have been only partially full, calculations show that on entering Lock No. 8, the vessel's metacentric height (GMf) was approximately 1.46 m (4.78 ft.).

As fire-fighting efforts progressed, expended water from fire hoses deployed in the loop belt casing, hold No. 3 and tunnel, accumulated on the tank top. Calculations show that shortly after leaving Lock No. 8, the vessel had only a slight trim aft and that the free-surface effect of some 163 tonnes of expended water reduced her GMf to approximately 0.46 m (1.52 ft).

The accumulation of expended fire-fighting water continued and in order to counteract its increasing free-surface effect water was pumped into No. 4 P & S ballast tanks, while the vessel was being manoeuvred toward Coal Dock No. 16. The vessel trimmed by the stern and water on the tank top then gravitated aft reducing its free-surface area which, together

with the effect of the weight of water ballast in the bottom of the No. 4 tanks, increased the vessel's GMf to approximately 0.69 m (2.28 ft).

After leaving Lock No. 8, fire damage to the plastic ballast piping allowed water to gravitate from the wing of No. 4 P to the bottom of No. 3 P tank, causing a substantial increase in free-surface effect. (See Figure No. 2). Because of fire damage to the hydraulic systems controlling the ballast tanks valve actuators, water also entered No. 2 and 3 tanks while ballasting of the No. 4 tanks was being carried out. The actual quantity of misdirected ballast was not immediately known, however, details recorded later indicate the water remained below tank top level and consequently caused a further reduction of transverse stability because of its free-surface effect. Fire-fighting continued, and calculations show that by the time some 508 tonnes tons of water had accumulated on the tank top, the vessel's GMf was reduced to approximately 0.22 m (0.74ft.).

Because of the fire and dense smoke, the loop belt casing and tunnel were largely inaccessible and the precise quantity and fore and aft extent of the water on the tank top were not known. Based on the vessel's after trim of about 0.91 m (3.0 ft.) and the concurrently reported location of fire-fighting water on the tank top in way of the vertical maintenance trunk at the after end of hold No. 2, it is estimated that at that time the flooding amounted to some 1026 tonnes. Later when the loop belt casing became accessible, the depth of water at the after port side of the tunnel was found to be about 1.14 m (3.75 ft.); based on a port heel of some 2.5°, the depth at the centreline of the tunnel is estimated to have been 0.78 m (2.58 ft.), and the flooding to have increased to about 1219 tonnes.

While details of the quantity and fore and aft extent of flooding on the tank top were not precisely recorded, post-casualty calculations show that the vessel retained positive initial transverse stability throughout the fire-fighting and flooding operations. Small changes of trim caused large variations in the free-surface effect of the water on the tank top, and it would appear that the vessel's GMf varied from about 0.05 m (0.16 ft.) to 0.13 m (0.48 ft.) just before and during the flooding. Later, as fire-fighting and cooling-off water continued to accumulate, the vessel's draught and trim increased and the GMf was raised to approximately 0.23 m (0.76 ft.).

In this regard, post-casualty calculations also indicate that had ballasting of No. 4 P & S tanks not been possible and no significant after trim established, positive initial

transverse stability would have been lost had the accumulated fire-fighting water not gravitated aft but extended throughout the length of the tunnel.

As a precautionary measure prior to the flooding of the tunnel, the depth and nature of the canal bottom alongside the wharf were verified. The depth of water, some 9.15 m (30'0"), in conjunction with the vessel's draught, was such that bottom contact of her port side turn of bilge would restrict any port side heel or roll to approximately 3.6°. In the event, those onboard considered that no bottom contact was made and no record was kept of the initial roll taken by the vessel. In order to induce the heel to port, water ballast was reportedly discharged from No. 3 tank, however, no record of the actual quantity was kept. The depths of floodwater noted at the after end and port side of the tunnel after the fire was extinguished together with post-casualty calculations, indicate a port heel of approximately 2.5°.

In this instance, because some ballasting was possible before complete control of the ballasting system was lost, the vessel trimmed by the stern, reducing the free-surface area of the accumulated water on the tank top, and sufficient positive initial transverse stability was maintained to prevent any excessive heel developing. Furthermore, because the vessel was alongside in shallow water, the partial flooding of the tunnel and induced heel could be performed with confidence, knowing that any excessive heeling brought about by undetected or underestimated flooding or transfer of water would be curtailed by the early bottom contact of the port side turn of bilge.

After the intentional flooding of the tunnel was completed some fire-fighting efforts were maintained in the tunnel and cooling-down water was still applied to the cargo and hot structure. The water expended during these activities gravitated aft, increased the after trim and reduced the length of the free-surface waterplane on the tank top.

On completion of all fire-fighting the floodwater, expended fire-fighting water, cooling-down, wash-down and existing contaminated bilge water amounting to some 1626 tonnes was pumped ashore and the vessel's transverse stability restored.

It may be noted that, should a vessel be at sea and fire damage to the hydraulic systems in the tunnel preclude any ballasting, the option of extinguishing a tunnel fire by intentionally flooding the tunnel may not be feasible. Loss of control of the ballasting systems in conjuction with the increasing free-surface effect of an accumulation of expended fire-fighting or flooding water on the cargo conveyor tunnel

tank top could, depending on her initial loading condition and trim, put any self-unloading vessel at risk.

8. Weather conditions

The weather remained settled and practically calm throughout September 27, 1989, and did not hinder ship manoeuvring or fire-fighting efforts. The nearest weather recording station at Niagara District Airport recorded the following:

Temperatures:	13°C high, 3°C low.
Wind at 1200:	North at 4km/hr.
Wind at 1900:	Calm.
Wind at 2200:	South at 7km/hr.
Wind at 2300:	South at 9km/hr.
Wind at 2400:	Calm.

9. Cargo conveyor belt fires on Self-unloaders

Since 1975, there have been six reported fires in the cargo conveyor belt systems of Canadian Great Lakes self-unloading vessels, and this is the second major fire to have occurred while a vessel was in the Welland Canal system.

In 1986, a fire attributed to hot welding slag causing the ignition of the cargo conveyor belts in the loop belt casing of the Great Lakes self-unloading vessel "ALGOSOO" while laid-up in the Welland Canal, resulted in extensive damage to the unloading gear, engine room and accommodation. Subsequently, on January 2, 1987, the Ship Safety Branch of Canadian Coast Guard issued Ship Safety Bulletin N° 1/87, which stated in part:

> Subject: Fire Hazard in Self-Unloaders.
>
> The purpose of this Bulletin is to draw attention to the potential fire hazards associated with conveyor casings and tunnels of self-unloading type vessels.
>
> 5) Ships crews should be drilled, at the onset of the shipping season, in such areas to ensure that they can effectively fight a fire using the existing fire-fighting hydrants and hoses.
>
> 6) It is advised that, should it be evident that effective measures are not possible, suitable corrective action should be taken to improve the system within a reasonable period of time.

The safety bulletin was circulated to all interested companies including the owners of the "H.M. GRIFFITH", and to CCG regional offices. The regional offices were also advised that at the time of the safety inspections immediately prior to the start of the shipping season, fire drills should be conducted and witnessed to ensure that ships' crews could effectively fight fires in the tunnel spaces and that such drills be recorded in the vessels' safety inspection records.

Safety inspection reports and the Record of Boat and Fire Drills logs of the "H.M. GRIFFITH", show that fire drills conducted prior to the begining of the 1987, 1988 and 1989 shipping seasons were carried out with simulated fires in the electrical control room, galley and incinerator room respectively. No simulated tunnel fire drills were carried out on the "H.M. GRIFFITH", and reportedly none of her crew had participated in such a drill on any other self-unloading vessel.

10. Vessel certification and crew qualifications

At the time of the fire, the vessel's current Radio Inspection Certificate, Load Line Certificate and CCG Safety Inspection Certificate (SIC 19), were valid and on display in the wheelhouse.

The master and ship's officers held appropriate and valid nautical and marine engineering certificates in accordance with the regulatory requirements of the Canada Shipping Act and, together with 12 of the crew, also held valid Marine Emergency Duties, (MED), certificates, of various grades.

Findings

Sometime between 1200 and 1230, September 27, 1989, the cargo conveyor belt on the port side of the conveyor tunnel of the Canadian Great Lakes self-unloading vessel "H.M. GRIFFITH", caught fire while she was in Lock N°8 of the Welland Canal, causing extensive damage. All indications of the precise cause and location of the start of the fire were obliterated during the blaze, however, it would appear that the following factors caused or contributed to the fire:

- sparks or hot slag from oxy-acetylene burning operations caused a discarded cleaning cloth to smoulder and later ignite;

- the edges of the cargo conveyor belts were subject to chafe, causing them to become readily flammable;

- hydraulic oil released from fire damaged hydraulic

systems in the tunnel which fuelled and helped spread the fire to the centre conveyor belt;

- the design of the cargo conveyor belt system is such that the tunnel loop belt casing cannot be made airtight in the event of fire;

- operation of the tunnel mechanical ventilation system increased the air supply to the fire, but afforded easier access to its source, and

- access to the fire was limited to the forward end of the tunnel, some 90 m (300 ft) from the seat of the fire, which hampered and restricted fire-fighting efforts.

The fire was suppressed by:

- the deliberate flooding of the tunnel and heeling of the vessel which immersed and extinguished the burning conveyor belts.

Other Findings

When discovered, the fire was well established and producing dense black smoke.

Only one length of 25 mm (1") diameter wash-down fire hose was available in the tunnel when the fire was discovered.

No. 4 P. & S. ballast tanks were partially filled before control of the ballasting system was lost, the vessel trimmed by the stern and the accumulated fire-fighting water on the tank top gravitated aft reducing its free-surface effect such that the vessel maintained positive initial stability.

Fire damage to PVC ballast piping located inside ballast tanks and adjacent to the tunnel sides, in conjunction with the absence of tank end isolating valves, allowed ballast water to gravitate from No. 4 P to 3 P ballast tanks.

Operation of the ballasting system was lost because of fire damage to the ballast valves hydraulic control system located in the tunnel.

Depending upon the initial loading and trim of such a self-unloading vessel, the free-surface effect of an accumulation of expended fire-fighting water on the tank top of the cargo conveyor tunnel area could quickly reduce her initial transverse stability to such an extent that her safety is put at risk.

Regulations do not require the provision of full stability information for such vessels, however the absence of this information poses a serious obstacle to evaluation of their stability characteristics in emergency situations.

Flooding of the cargo conveyor tunnel and deliberately induced heeling were carried out with the knowledge that because of the depth of water under the vessel, early bottom contact would prevent any excessive angle of heel developing.

Conveyor tunnel and loop belt casings simulated fire drills called for in Ship Safety Bulletin No. 1/87, were not performed.

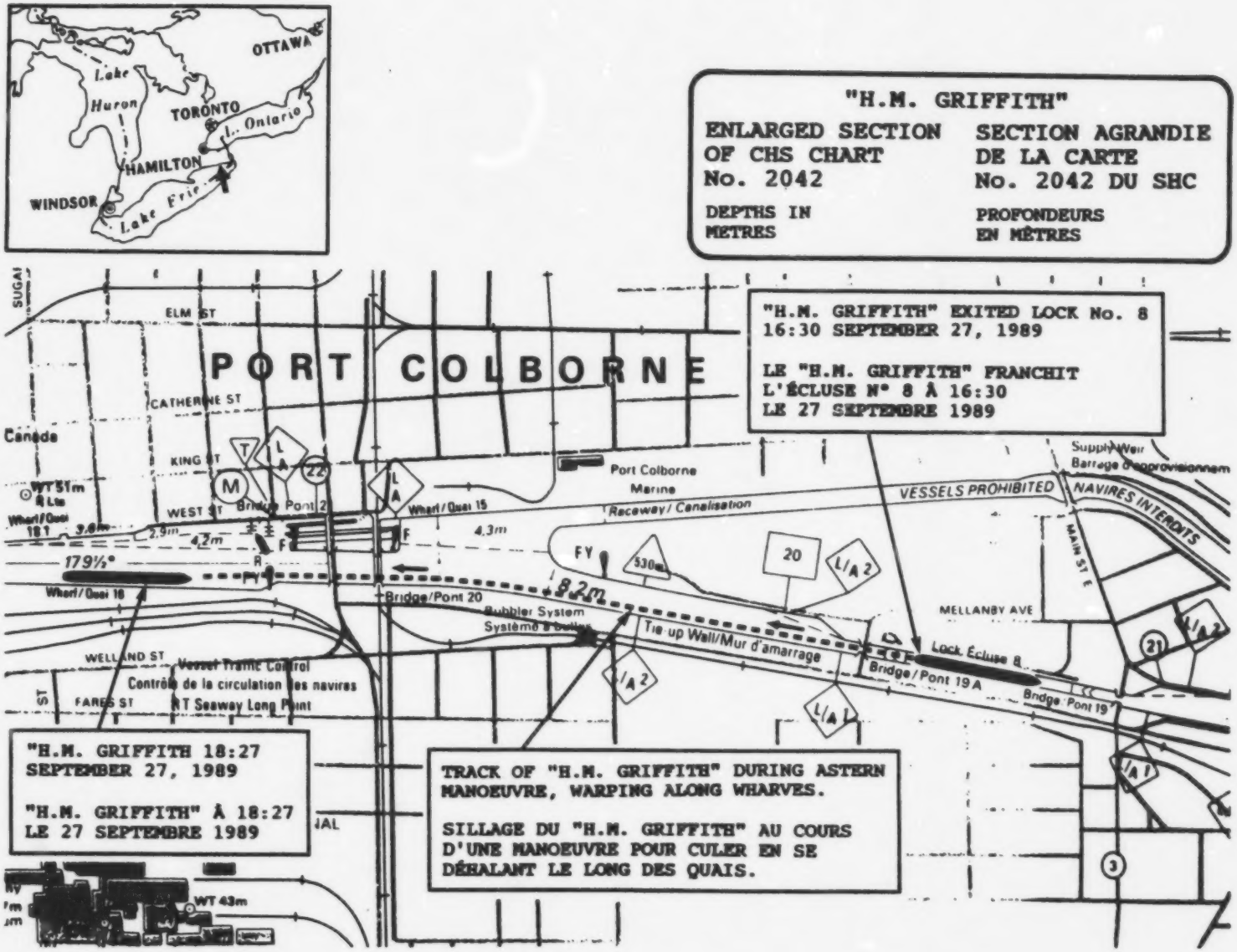
The officers and crew of the "H.M. GRIFFITH", reacted quickly to the General Alarm, immediately attacked the fire with the equipment available and later guided other fire-fighters throughout the fire fighting efforts.

Once alerted, the PCFD responded promptly with fire appliances and equipment, and carried out fire-fighting efforts in a disciplined manner for some 12 hours.

There was no pollution during the fire-fighting, and all contaminated water was later pumped ashore into tanker trucks and transported to an approved disposal site.

Marine Casualty Investigations
110 O'Connor Street
Ottawa, Ontario
K1A 0N5

OTTAWA, ONTARIO
MAY 1990.

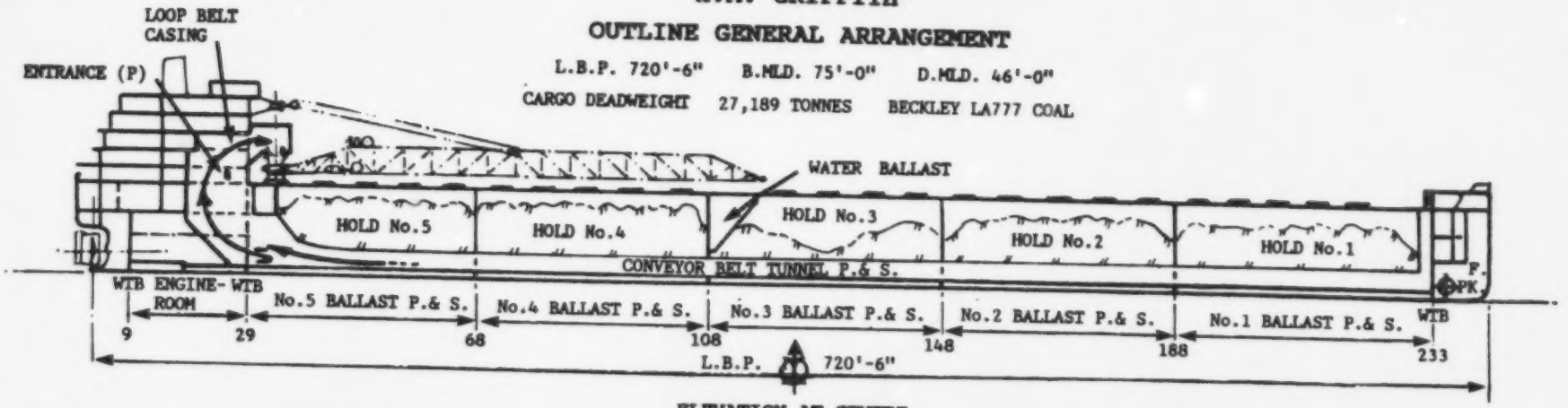

OTTAWA
Lake Huron
TORONTO
L. Ontario
HAMILTON
WINDSOR
Lake Erie
"H.M. GRIFFITH"
ENLARGED SECTION OF CHS CHART No. 2042
SECTION AGRANDIE DE LA CARTE No. 2042 DU SHC
DEPTHS IN METRES
PROFONDEURS EN MÈTRES
"H.M. GRIFFITH" EXITED LOCK No. 8
16:30 SEPTEMBER 27, 1989
LE "H.M. GRIFFITH" FRANCHIT
L'ÉCLUSE N° 8 À 16:30
LE 27 SEPTEMBRE 1989
PORT COLBORNE
ELM ST
CATHERINE ST
KING ST
WEST ST
Canada
Port Colborne Marine
Raceway / Canalisation
VESSELS PROHIBITED
NAVIRES INTERDITS
Supply Weir
Barrage d'approvisionnem
MAIN ST E
MELLANBY AVE
Wharf / Quai 15
Wharf / Quai 18
Bridge / Pont 20
Bubbler System
Tie up Wall / Mur d'amarrage
Lock Écluse 8
Bridge / Pont 19A
Bridge / Pont 19
WELLAND ST
Vessel Traffic Control
Contrôle de la circulation des navires
FARES ST
CT Seaway Long Point
WT 43m
"H.M. GRIFFITH 18:27
SEPTEMBER 27, 1989
"H.M. GRIFFITH" À 18:27
LE 27 SEPTEMBRE 1989
TRACK OF "H.M. GRIFFITH" DURING ASTERN MANOEUVRE, WARPING ALONG WHARVES.
SILLAGE DU "H.M. GRIFFITH" AU COURS D'UNE MANOEUVRE POUR CULER EN SE DÉHALANT LE LONG DES QUAIS.

"H.M. GRIFFITH"

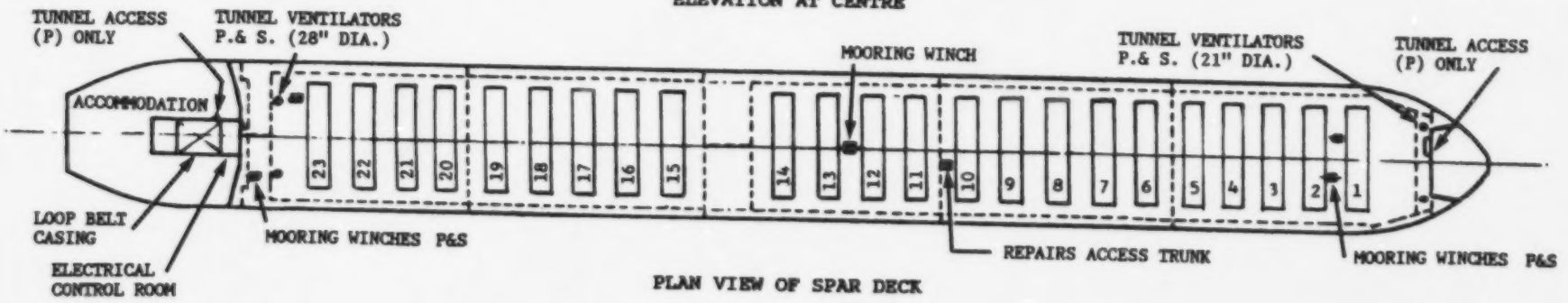
OUTLINE GENERAL ARRANGEMENT

L.B.P. 720'-6" B.MLD. 75'-0" D.MLD. 46'-0"

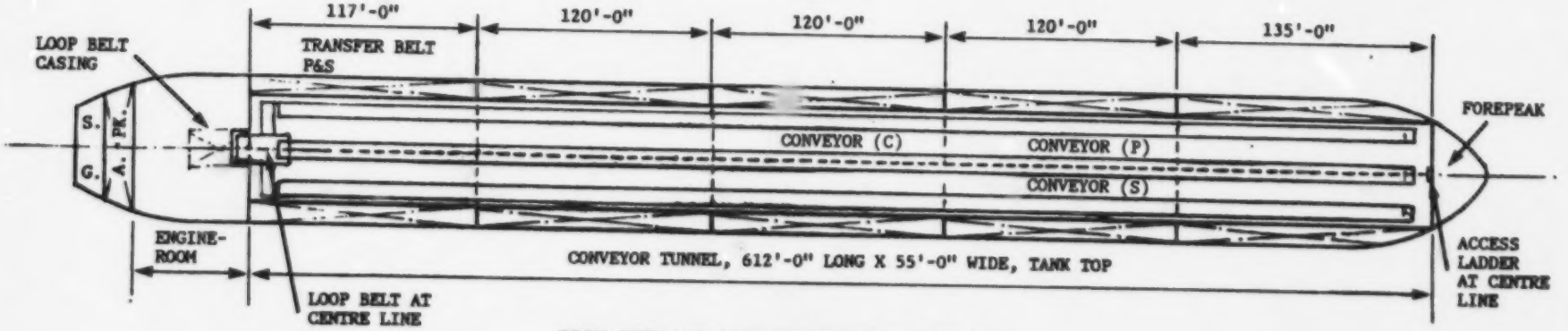
CARGO DEADWEIGHT 27,189 TONNES BECKLEY LA777 COAL



ELEVATION AT CENTRE



PLAN VIEW OF SPAR DECK

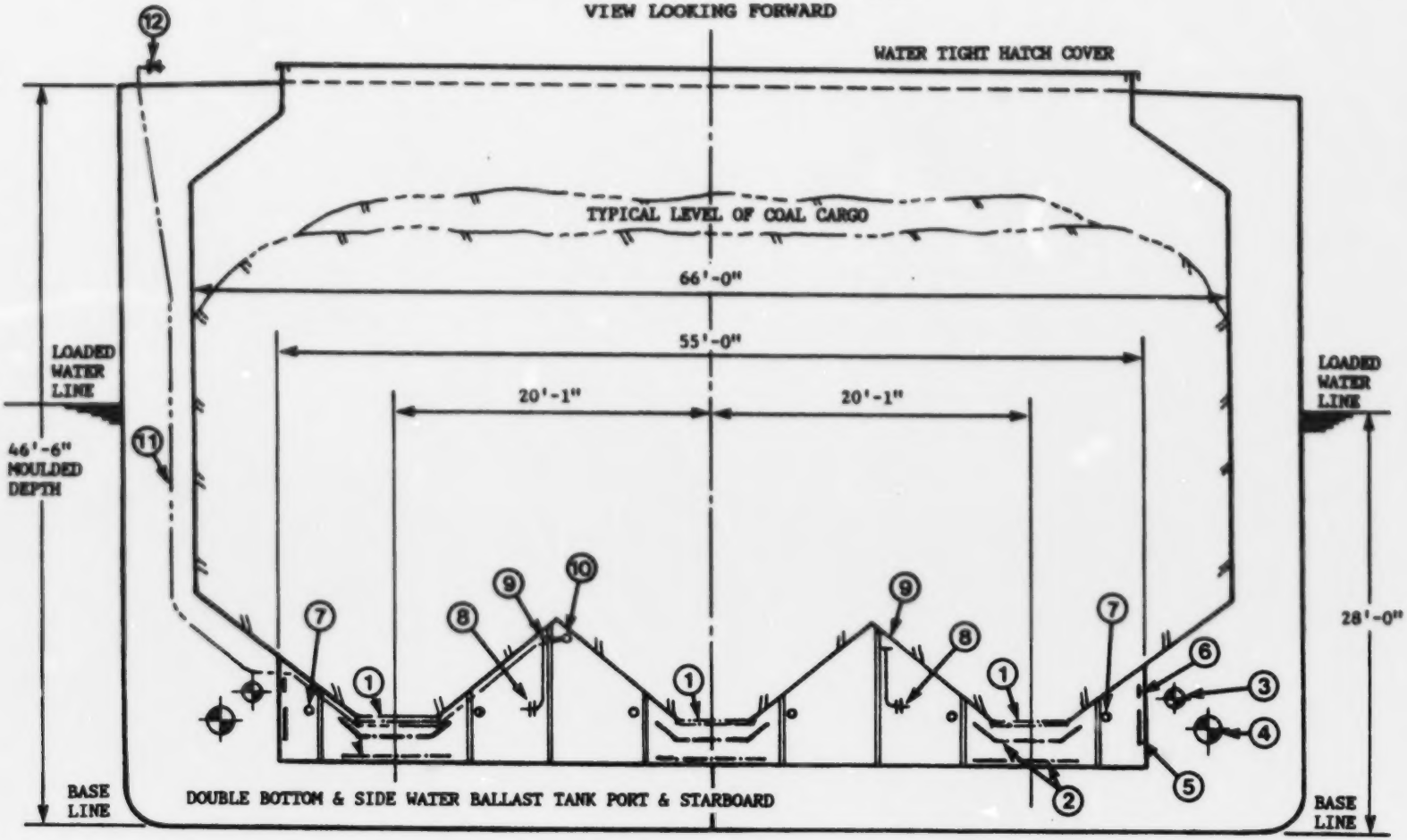


PLAN VIEW AT CONVEYOR TUNNEL TANK TOP

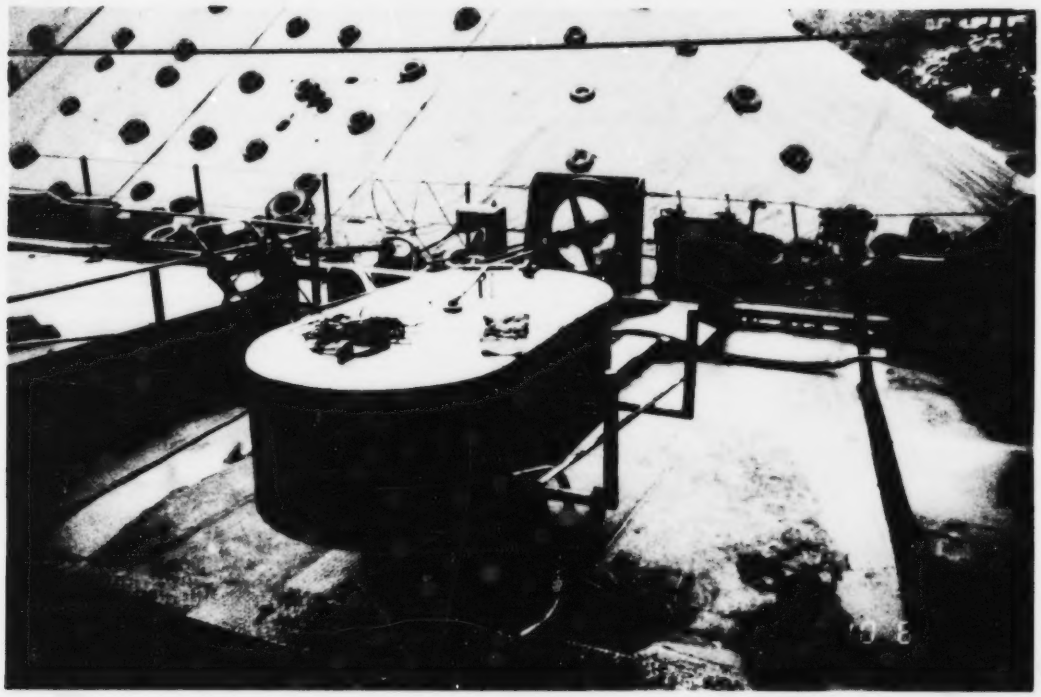
"H.M. GRIFFITH"

TYPICAL HOLD CROSS SECTION

VIEW LOOKING FORWARD



1. SLIDING CARGO HOPPER GATES PORT, CENTRE & STARBOARD
2. UPPER & LOWER CONVEYOR BELTS PORT, CENTRE & STARBOARD
3. 16" DIA. BALLAST STRIPPING PIPING PORT & STARBOARD (PLASTIC)
4. 20" DIA. BALLAST MAIN PIPING, PORT & STARBOARD (STEEL)
5. WATER TIGHT MANHOLE TO BALLAST TANKS, PORT & STARBOARD
6. BALLAST PIPING HYDRAULIC CONTROLS, PORT & STARBOARD
7. TUNNEL TOP HYDRAULIC VIBRATORS PORT & STARBOARD
8. 1" DIA. TUNNEL WASH/DOWN, FIRE HOSE CONNECTION, PORT & STARBOARD
9. 2" DIA. TUNNEL WASH/DOWN, FIRE MAIN PIPE, PORT & STARBOARD
10. 1½" DIA. FIRE MAIN PIPING (PORT SIDE ONLY)
11. 2" FIRE MAIN BRANCH PIPE (PORT SIDE ONLY)
12. 2" DIA. FIRE MAIN HYDRANT (PORT SIDE ONLY)

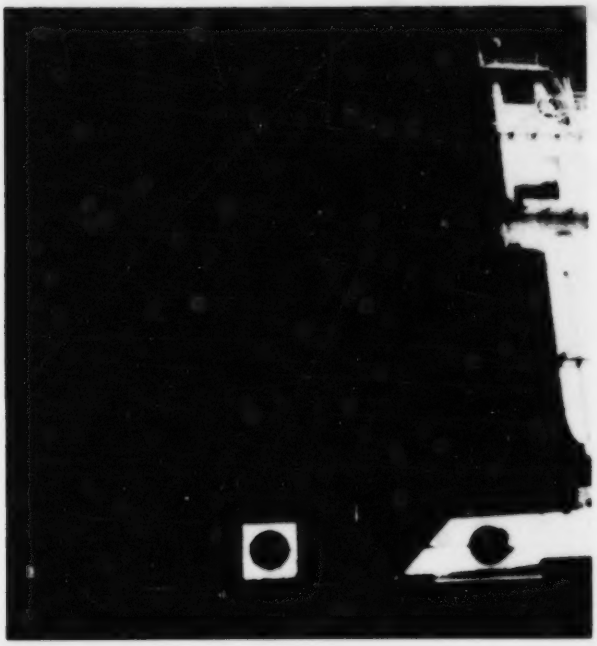


Cargo conveyor tunnel 28" diameter after ventilation fan.

Tunnel du convoyeur de cargaison - Ventilateur arrière de 28" de diamètre.

"H.M. GRIFFITH" during unloading operation Sept. 30, 1989.

"H.M. GRIFFITH" durant le déchargement le 30 septembre 1989.



Black smoke emerging from loop belt casing and tunnel ventilators.

Fumée noire se dégageant du tambour de la bande de circulation et des ventilateurs du tunnel.

Black smoke from loop belt casing and ventilators entering accommodation.

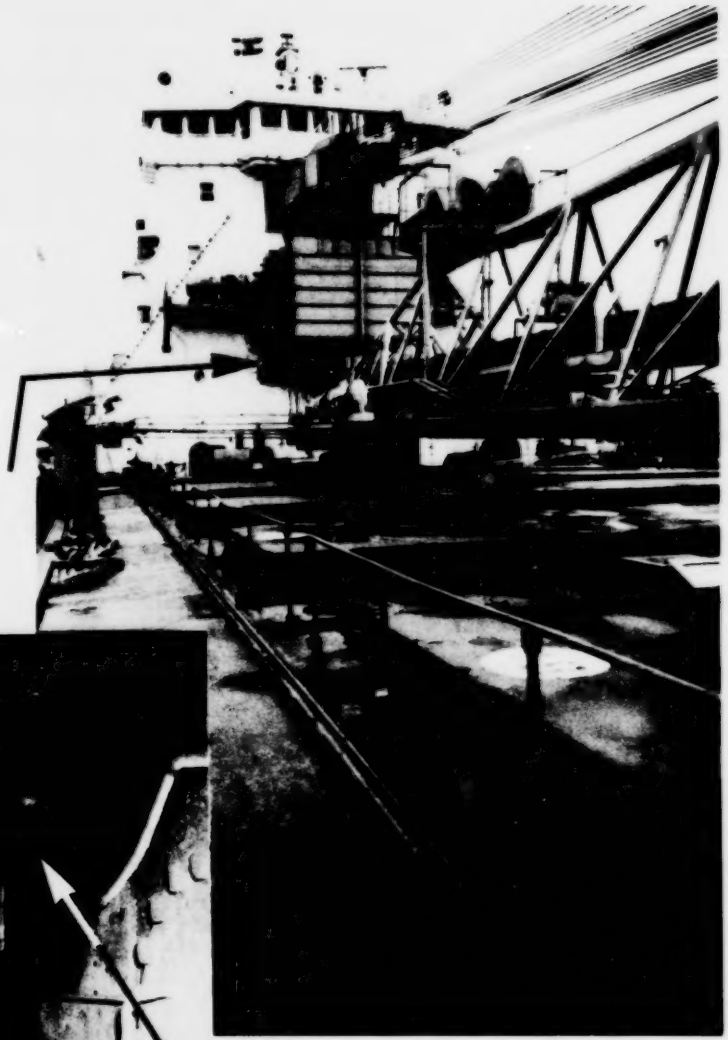
Fumée noire du tambour de la bande de circulation et des ventilateurs pénétrant dans les emménagements.

Smoke emerging from belt loop casing and ventilators while vessel is in Lock No. 8.

Fumée se dégageant du tambour de la bande de circulation alors que le navire est dans l'écluse N° 8.

View of cargo conveyor unloading boom and bride front.

Vue de la sauterelle de déchargement du convoyeur de cargaison et de l'avant de la passerelle.



Fire damage to ballast control valve hydraulic system in tunnel

Avaries au circuit hydraulique du robinet de contrôle de ballast du tunnel

Ballast valve hydraulic actuator control

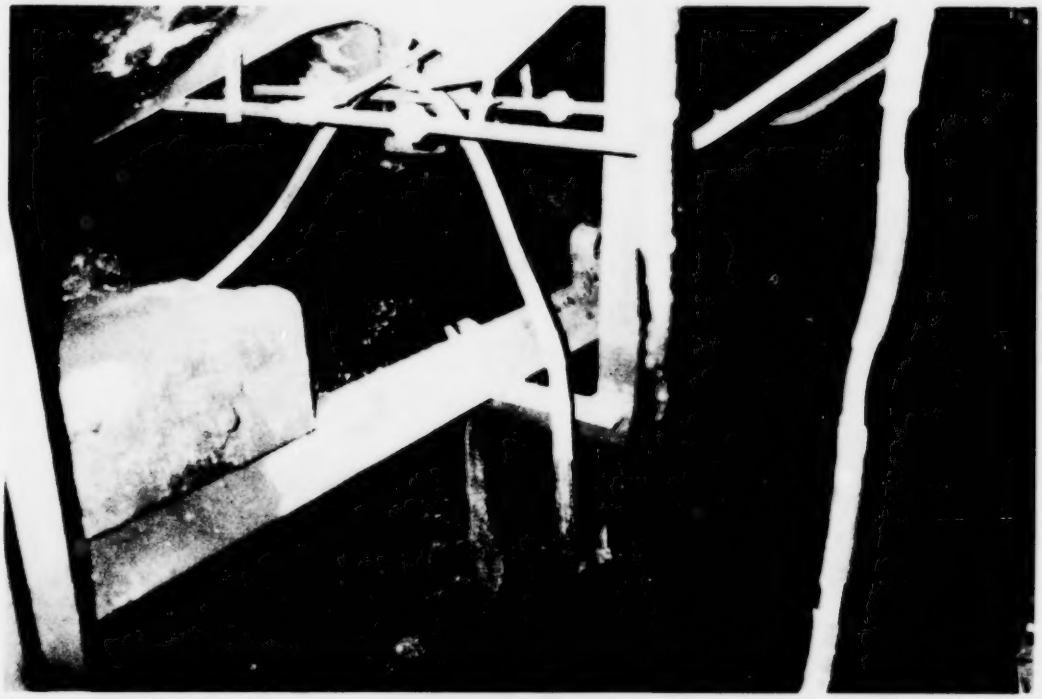
Commande hydraulique à distance du robinet de ballast

Fire damage to ballast control valve hydraulic system in tunnel.

Avaries au circuit hydraulique du robinet de contrôle de ballast du tunnel.

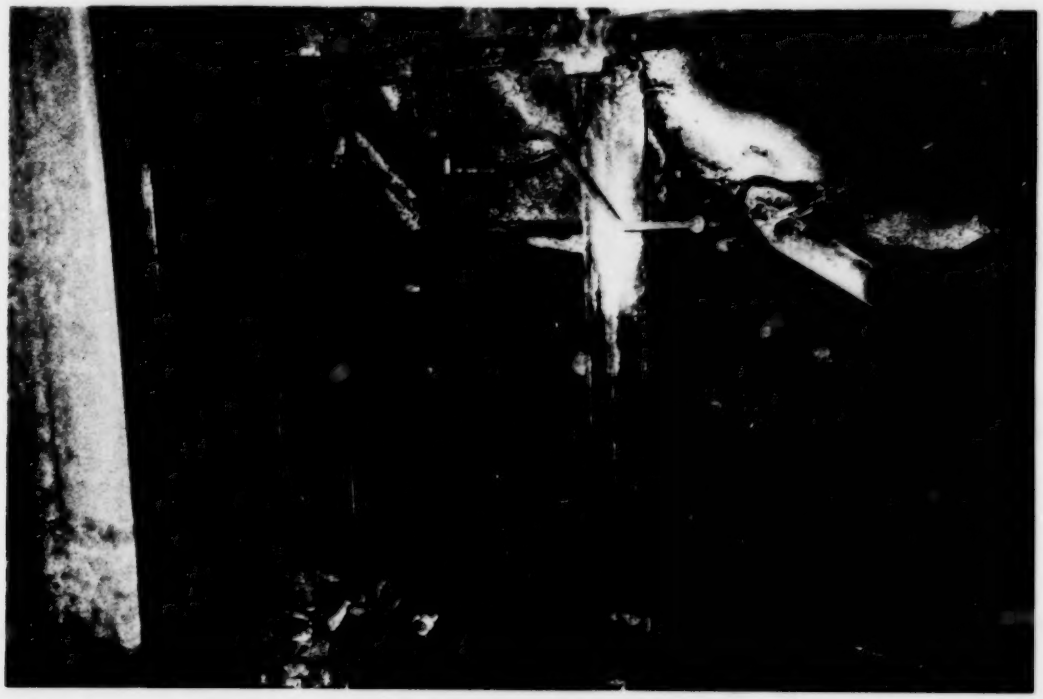
Fire damage to hydraulic and electrical systems in tunnel.

Avaries aux systèmes hydraulique et électrique du tunnel causées par l'incendie.



Fire damage to hopper gate hydraulic system and port side conveyor belt.

Avaries au clapet du système hydraulique et à la bande du convoyeur de cargaison, côté bâbord, causée par l'incendie

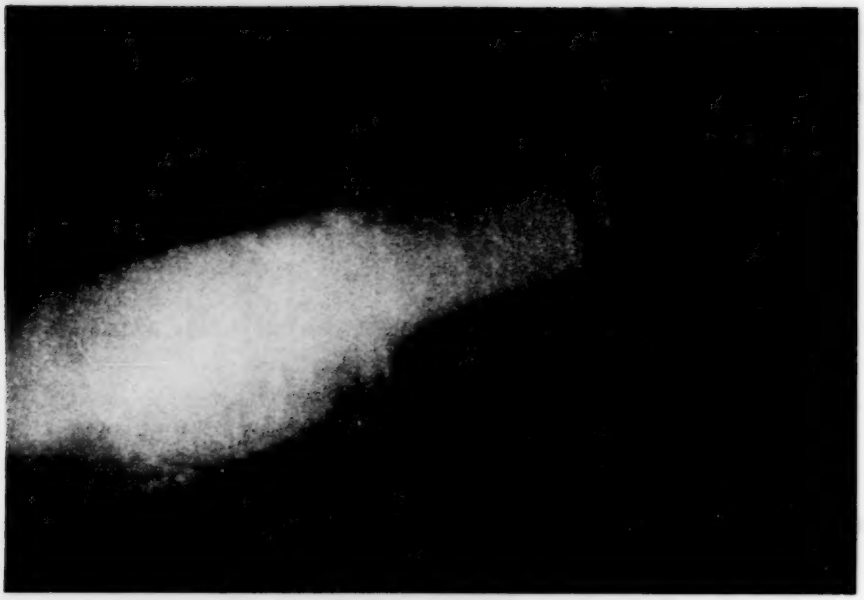


Fire damage to port side conveyor belt and rollers in tunnel.

Avaries à la bande du convoyeur, côté bâbord, et aux rouleaux de tunnel causées par l'incendie.

Fire damage to electrical cables and lighting system in tunnel.

Avaries aux câbles électriques et au système d'éclairage du tunnel causées par l'incendie.



16" diameter PVC ballast stripping pipe in No. 4 port ballast tank, damaged and ruptured by heat from fire in tunnel.

Collecteur d'assèchement en PVC d'un diamètre de 16" dans les citernes de ballast bâbord N° 4 endommagé et rupturé par la chaleur de l'incendie du tunnel.

16" diameter PVC ballast stripping pipe in No. 3 port ballast tank, damaged and ruptured by heat from fire in tunnel.

Collecteur d'assèchement en PVC d'un diamètre de 16" dans les citernes de ballast bâbord N° 3 endommagé et rupturé par la chaleur de l'incendie du tunnel.